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Chapter 10

On-Farm Wheat Drying and Storage

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Currently, a limited amount of wheat is harvested at high grain moisture content and dried on-farm in Arkansas. A majority of the wheat is harvested with grain moisture less than 14% and transported directly to grain terminals with no need for drying. However, there has been a dramatic increase in the number of on-farm storage and drying systems in the past few years that could be used to dry and store wheat. There are several reasons that producers may consider harvesting wheat at high moisture and drying the grain. Double-crop soybeans are normally planted following wheat harvest in Arkansas. Double-crop soybean yields are often maximized by early planting. Harvesting wheat at high moisture and drying could allow double-crop soybeans to be planted a week or more earlier, likely increasing soybean yields significantly. Harvesting wheat at high moisture also allows producers to harvest timely and possibly avoid rainfall immediately prior to harvest, which tends to lower grain test weight and quality. Drying and storing wheat also gives producers greater flexibility in their marketing programs. This chapter explores the basics of on-farm wheat drying and storage.

Drying Basics

Wheat Moisture Content

Moisture content of wheat is very important in deciding whether grain can be safely stored. Wheat moisture content is expressed as the percentage weight of water in the wet grain. The weight of the water in the wheat grain is determined by measuring the wet weight of the grain, drying the grain until all the water is removed and then reweighing the grain to determine dry weight. The weight of the water is determined by subtracting the dry weight from the wet weight (see the equation below). To determine wheat moisture content from a bin or truckload in order to get a useful moisture content evaluation, a representative sample must be collected (typically from several locations within the load). The sample should be handled and stored properly to avoid moisture content changes until the measurement is conducted. Wheat moisture content can be determined by direct or indirect methods. Direct methods include the oven drying method. This method could be used to determine moisture content by measuring the wet and dry weight of the same sample, then substituting these values in the following equation:

Moisture content % = (wet weight – dry weight) / (wet weight) x 100%

Indirect methods for determining wheat moisture content include moisture meters where the wheat moisture content is determined as a function of grain electrical properties. Typically, the moisture meters must be calibrated periodically using the oven method to obtain reliable moisture measurements. Indirect methods usually provide a moisture content reading instantaneously where direct oven methods can require one to three days to provide a reading. The oven method is considered the most accurate way to determine grain moisture content.

Equilibrium Moisture Content

In order to dry wheat, a high flow rate of air (heated or unheated) is typically forced though the grain bed. The air is used as a medium to carry

away moisture from the grain. The air temperature and relative humidity (RH) determine how much moisture the air can hold and, along with airflow rate (or velocity), determine the drying time, required drying costs and the final grain moisture content. Air at a specific temperature and relative humidity continually passing through the wheat will cause the wheat to dry to a specific moisture content since the wheat moisture will eventually achieve a state of equilibrium with the air. This property is called "Equilibrium Moisture Content" (EMC). Thus, temperature and relative humidity properties of the drying air determine the wheat's final moisture level. Table 10-1 indicates the EMC values of soft red winter wheat in equilibrium with air at various temperatures and relative humidity levels. Arkansas wheat producers primarily grow soft red winter wheat (Figure 10-1).

Table 10-1. Equilibrium moisture content of soft red winter wheat.

Temperature (°F)	Relative Humidity (%)						
	30	40	50	60	70	80	90
40	9.6	10.9	12.1	13.3	14.6	16.1	18.1
50	9.4	10.6	11.8	13.0	14.2	15.7	17.6
60	9.1	10.4	11.5	12.7	**13.9**	15.3	17.2
70	8.9	10.1	11.3	12.4	13.6	15.0	16.9
80	8.7	9.9	11.0	12.1	13.3	14.7	16.5
90	8.5	9.7	10.8	11.9	13.0	14.4	16.2
100	8.4	9.5	10.6	11.7	12.8	14.1	15.9

To illustrate the use of the EMC table, assume that air at a relative humidity of 70% and temperature of 60°F is forced through a bed of wheat. Soft red winter wheat will not dry below moisture content of 13.9%. If the air at 60°F and 70% RH is passed through a heater and heated to 80°F, not only will the temperature increase, but the RH will decrease to about 35% and the EMC decreases from 13.9% to less than 9%. Under heated conditions, the air can hold more water and will cause the wheat to dry to a lower moisture content. This is the key to achieving more reduction in moisture, but caution must be taken not to overdry the wheat causing damage and wasting money.

Figure 10-1. Soft red winter wheat.

Recommended Airflow Rate for Wheat Drying

As mentioned earlier, air is the medium used to carry moisture away from wheat during drying and conditioning. The air is typically forced into the bottom section of a bin under a perforated floor supporting the wheat using one or more fans. This open area is called the plenum. The fans are mounted to the plenum using a transition that allows efficient pressurization of the air. The plenum provides even distribution of air flowing through the bed of wheat. Even air distribution is critical to allow complete drying of wheat and avoid "hot spots" where sections of wheat do not dry properly resulting in spoilage. Grain producers should select the manufactured fan that best fits their drying needs. Oversizing the fan leads to unnecessary energy consumption in the form of electricity from the fan motor and gas or electricity from the air heater. The greater the airflow rate, the more energy required to heat the air to a specific temperature. Also, higher airflow rates through wheat result in higher pressure requirements for the fan resulting in higher purchase costs for the fan and less efficient operation. On the other hand, undersizing the fan size will cause too little airflow resulting in drying being too slow. The airflow rate through wheat and air temperature directly control the drying rate. The higher airflow rate and the higher temperature accelerate the drying rate and increase the cost. Proper dryer operation allows wheat to reach a sufficiently low moisture content faster to prevent spoilage. Properly designed dryers optimize the balance between airflow rate and air temperature to dry wheat to the proper moisture content to maximize quality while minimizing overall costs.

Grain drying fans are classified as either axial flow or centrifugal flow. Each type of classification could be used to optimize the airflow rate and minimize the energy consumption for maintaining grain quality. In both types, air is forced into the bin by the fan. Axial-flow fans move air parallel to the axis or impeller shaft. This type of fan is suitable for grains that create low static pressure, less than 4 inches of water. This is generally not the case for wheat unless the bed depth is shallow. The axial-flow fans, however, could provide adequate airflow for aeration of already dried wheat, which requires much less airflow than when drying. Axial-flow fans also typically create much more noise during operation than centrifugal fans, which should be considered when locating drying facilities near residences.

The second type of grain drying fan is the centrifugal fan. In centrifugal fans, air enters one end of the impeller parallel to the shaft and exits perpendicular to the shaft. Centrifugal fans used for grain drying and storage generally have backward-curved blades. They are usually the most efficient type of fan when static pressure is greater than 4 inches of water and are typically capable of generating much greater pressure than axial fans. Because of high resistance to airflow generated by wheat, centrifugal fans are the ideal fans to use for drying operations, which generally require moving airflow rates of 1 to 4 cfm/bu. Centrifugal fans also operate with less noise than axial fans.

The actual amount of air needed to dry wheat depends on its initial moisture content. Table 10-2 shows the minimum recommended airflow rate to dry wheat at various levels of initial moisture content. Fans sized specifically for corn or soybeans will not move enough air for wheat placed in bins at the same grain bed depths due to the higher static pressure developed by wheat.

Table 10-2. Recommended minimum airflow rates for drying wheat.

Initial Moisture Content	Airflow Rate (cfm per bushel)
11% to 13%	0.5
13% to 15%	1.0 cfm/bu
15% to 18%	2.0 cfm/bu
18% to 20%	>3.0 cfm/bu

Wheat Shrinkage

Wheat kernels contain dry matter and water. The dry matter translates to the actual value of the wheat. A base moisture content of 13.5% is typically used to price wheat. Variations of the wheat moisture content change the weight of the water in the wheat and its weight per standard bushel as shown in Table 10-3.

When wheat is delivered to the elevator at moisture content above its base standard, buyers apply a "shrink factor" to adjust the quantity for the excess moisture. This is because wheat buyers will not pay the price of excess water. Applying the shrink factor approximates the equivalent number of bushels that would be in the load if wheat were dried to the base moisture content. Conversely, some farmers often deliver wheat to the elevator at moisture levels below the base. There will be no compensation factor increasing the price of the wheat in this case, so it is very important to avoid overdrying of wheat to prevent lowering its value.

Table 10-3. Wheat weights of one market standard bushel at a moisture content of 13.5%.

Moisture Content (%)	Weight (lb/bu)	Moisture Content (%)	Weight (lb/bu)	Moisture Content (%)	Weight (lb/bu)
30.0	74.14	21.0	65.70	13.0	59.66
29.0	73.10	20.0	64.88	12.0	58.98
28.0	72.08	19.0	64.07	11.0	58.31
27.0	71.10	18.0	63.29	10.0	57.67
26.0	70.14	17.0	62.53	9.0	57.03
25.0	69.20	16.0	61.79	8.0	56.41
24.0	68.29	15.0	61.06	7.0	55.81
23.0	67.40	14.0	60.35	6.0	55.21
22.0	66.54	**13.5**	**60.00**	5.0	54.63

The following example will provide an illustration of applying the shrink factor on wheat. Suppose a farmer harvests a portion of a field and dries the wheat to the market standard moisture content of 13.5% and the dried wheat weighs 100,000 lbs. This means that the weight of the water in the wheat is 0.135 x 100,000 = 13,500 lbs. The weight of the dry matter in the wheat is 100,000 – 13,500 = 86,500 lbs. At 60 lbs per bushel at standard base moisture content of 13.5%, the farmer will get credit for 100,000 lbs/60 lbs per bu = 1,667 bu of wheat. At a price of $5 per bu, the farmer sells the wheat for $5/bu * 1,667 bu = $8,333.

Alternatively, suppose this same portion of the field is harvested and the wheat is dried to 16% moisture content. The farmer would still harvest 86,500 lbs of dry matter, but the wheat would now contain more water because of the higher moisture content. At 16% moisture content, the total weight of the wheat is now 102,976 lbs and contains 102,976 – 86,500 = 16,476 lbs of water. As mentioned earlier, the elevator will not be willing to buy excess water. The elevator applies the shrink factor to adjust the quantity. From Table 10-3, the market standard bushel weight at 16% moisture content is 61.79 lbs per bushel. The total bushels calculated accounting for the greater moisture content is now 102,976 lbs divided by 61.79 lbs per bushel equals 1,667 bu, which is the same as if the moisture content were 13.5%. The total price the farmer would receive remains the same at $8,333. However, the farmer would also need to pay drying costs to the elevator to remove the extra moisture.

If the farmer harvested the same portion of the field and overdried the wheat to a moisture content of 10%, then the total weight of the wheat is 96,111 lbs including dry matter and moisture. The overdried wheat is not adjusted for moisture, so the standard bushel weight of 60 lbs per bushel is used. A total amount of wheat is calculated to be 96,111 lbs divided by 60 lbs per bu = 1,602 bu. The farmer receives a price of 1,602 bu x $5/bu = $8,010 or about 4% less than if the wheat was at 13.5% moisture content. Costs are also added for the extra electricity and gas consumed removing the extra moisture from the grain during overdrying.

Wheat Drying Methods

In-Bin Drying

In-bin wheat drying processes can utilize either natural air (unheated) or low temperature air (slightly heated usually less than 10°F) to dry grain in bins (see Figure 10-2). The air is forced up through the grain with fans until the grain moisture content is sufficiently reduced. This is typically done in bins with a raised perforated floor to ensure even airflow, but can also be done using air ducts laid on the concrete bin floor prior to adding grain. Wheat is among the grains that offer high resistance to airflow requiring a significant pressure output from the fans, which is represented as static pressure in inches of water. In-bin drying methods used for other crops such as corn and soybeans can be adapted to work properly

Table 10-4. Number of wheat bushels in grain bins.

Level of Grain Depth (ft)	Bin Diameter (ft)						
	20	22	24	26	28	30	32
2	503	608	724	849	985	1,131	1,287
4	1,005	1,216	1,448	1,699	1,970	2,262	2,574
6	1,508	1,825	2,171	2,548	2,956	3,393	3,860
8	2,011	2,433	2,895	3,398	3,941	4,524	5,147
10	2,513	3,041	3,619	4,247	4,926	5,655	6,434
12	3,016	3,649	4,343	5,097	5,911	6,786	7,721
14	3,519	4,257	5,067	5,946	6,896	7,917	9,008
16	4,021	4,866	5,791	6,796	**7,882**	9,048	10,294
18	4,524	5,474	6,514	7,645	8,867	10,179	11,581
20	5,027	6,082	7,238	8,495	9,852	11,310	12,868

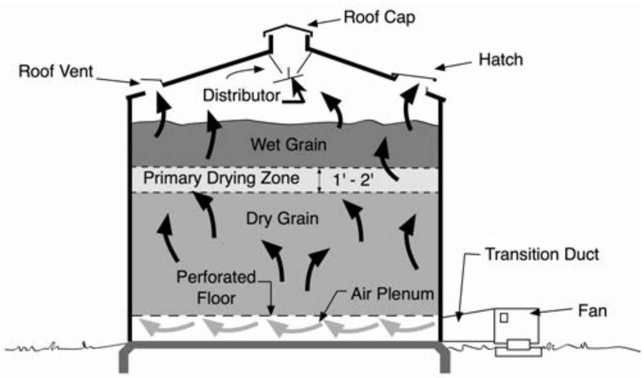

Figure 10-2. Grain bin.

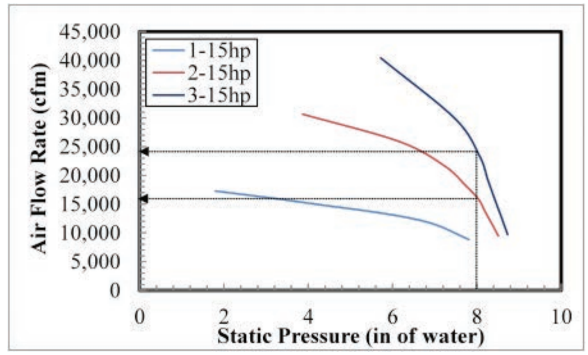

Figure 10-3. Single and multiple fan static pressure and airflow rates.

for wheat if some adjustments are made to compensate for wheat's high resistance to airflow. The simplest adjustment is to reduce wheat depth in the bin to half that normally used for corn or soybeans. In addition, the installation of appropriately sized centrifugal fans may help deliver higher airflow rates under higher static pressures.

Bin capacity measured in bushels of grain shown in Table 10-4 increases by increasing the bin diameter and/or the grain depth. For example, a grain bin with a 28-ft diameter filled to a level height of 16 ft can hold up to 7,882 bu of wheat. Increasing the grain depth increases the static pressure that the fan has to overcome to provide the same cfm/bu. For example, if air is delivered to a grain bin that holds 9,048 bu creating static pressure of 8 inches of water (see Figure 10-3), the airflow rate will not exceed 16,000 cfm (1.77 cfm/bu) using 2-15 hp fans or 24,000 cfm (2.65 cfm/bu) using 3-15 hp fans. It should be mentioned that for a 30-ft or 32-ft bin, wheat depths greater than 20 ft would generally reduce airflow rates to less than 1 cfm/bu even with the use of 3-15 fans. Accordingly, Table 10-5 can be used to select wheat depth for known moisture content and fan size.

If high moisture wheat is to be dried and stored in the same bin, extra care is advised. If the initial moisture content is 17% or more, use heat to dry the top layer to less than 17% before adding more wheat. Generally, moderate airflow (2-5 cfm/bu) along with a temperature rise of less than 20°F is required. Stirring devices, re-circulators or automatic unloading augers can be used to increase drying rate. After drying wheat to 17%, use unheated air to dry it to about 15%. During this period, run the fan continuously to provide uniform drying and moisture distribution within the wheat. Operate drying fans only during low humidity hours to finish drying to around 13%. This management scheme will minimize the amount of wheat overdrying in the bottom of the bin. It should be mentioned that excess heat could cause severe overdrying. Table 10-6 shows the approximate degrees of heat needed to dry wheat to 12% moisture content.

Table 10-5. Maximum safe drying depth for wheat with typical bin and fan combinations.

Bin Diameter	Fan Horsepower	Moisture Content of Grain Placed in the Bin			
		11%-13%	14%-15%	16%-17%	18%-20%
		Safe Depth of Grain – ft			
18	5	20	16-18	10-12	6-8
21	7.5				
24	10				
27	10				
30	15				
33	20				

Table 10-6. Approximate degrees of heat needed to dry wheat to 12% moisture content.

Plenum Temperature °F	Relative Humidity (%)						
	30	40	50	60	70	80	90
40	0	0	1	5	8	12	16
50	0	0	0	4	8	12	16
60	0	0	0	3	7	11	14
70	0	0	0	2	7	10	14
80	0	0	0	1	5	9	13
90	0	0	0	0	5	9	12
100	0	0	0	0	4	8	11

Batch and Continuous Flow Drying

High temperature batch or continuous flow dryers are usually used to dry large capacities of wheat. These units typically have very high airflow rates, and they do not require supplemental heat for daytime drying when harvesting wheat at the 18%-20% moisture range. If heat is used, the drying air temperature can be limited by cycling the burner on and off or by changing the gas burner orifices.

Advantages of On-Farm Wheat Drying

Wheat growers who utilize on-farm wheat drying and storage facilities, such as the one shown in Figure 10-4, list numerous advantages of the technology. Among these advantages is that on-farm grain drying and storage costs are typically less than commercial costs at the elevator. On-farm drying equipment capital costs are particularly justified if drying other crops can be conducted in addition to the wheat crop. Energy cost alone, i.e., electricity and liquid propane, ranges from 3 to 4 cents per bushel per point of moisture removed. On-farm drying may make it economically feasible to harvest wheat early at moisture content higher than the dockage level at a commercial dryer. Early harvest with proper on-farm drying can produce better quality wheat compared to wheat that is re-wetted in the field several times waiting for field drying to a dockage level. Additionally, it will allow producers to plant soybeans earlier for their double-cropping. On-farm drying and early harvest also reduce the risk of field losses to the grower and provide greater flexibility with scheduling harvest and drying. On-farm storage of dried wheat also provides the grower with the ability to wait until wheat prices peak before selling, potentially increasing profits.

Figure 10-4. On-farm grain drying and storage facility.

Disadvantages of On-Farm Wheat Drying

A few growers raise concerns regarding on-farm drying costs, which may be higher than commercial drying particularly when electrical demand costs are high. Wheat harvest occurs during the beginning of the water-pumping time when electric demand charges are higher than other times of the year. Some electrical power suppliers, however, may carry these demand charges forward for several months. Also, drying wheat comes at one of the busiest times of the farming season when proper management and monitoring of the drying process by the growers may not be practical. Generally, on-farm wheat drying and storage requires some skilled management in order to achieve effective drying, storage and insect management. Furthermore, there is high capital investment in equipment, which may fail to be justifiable if no other commodity shares the cost burden of drying equipment with wheat.

Wheat Drying Tips

The following are some tips that may help wheat producers achieve better grain quality while minimizing the drying cost:

- **Harvest wheat at 20% or less moisture content.** Wheat requires extra care for harvesting above 20% moisture, so this is the practical upper limit for drying. The more typical harvest moisture content is around 14% to 16%. Adjust the combine to minimize the amount of trash collected with the grain in order to reduce the pressure loss of air passing through it and increasing airflow rate.

- **Load grain into clean bins immediately after harvest.** Bins should be cleaned and sanitized prior to harvest to minimize insect problems. Move wheat from the field to grain bins as soon as possible. The amount of time before spoilage begins depends on grain moisture content and air temperature. A safe rule of thumb is to hold freshly harvested wheat in carts or trucks no longer than 12 hours. Warm air temperatures >80°F and higher grain moisture levels are the most critical factors for decreasing the time required for the grain to spoil.

- **Check the moisture content of each load of grain as it is placed in the drying bin.** There can be some variation in moisture content, but you need to know the average moisture content of the bin to determine the minimum necessary airflow needed and the allowable depth of grain in the bin.

- **Open air exits and start the fan as soon as the grain depth is about 1 foot deep on the perforated floor**. Be sure to use spreading devices or some other means to keep the grain leveled as the bin is being filled. If the grain is allowed to cone, there will be an increase of small particles in the center of the cone or central portion of the bin resulting in the air not being able to reach this grain because of increased resistance to flow. This makes it very hard to dry and control moisture uniformly in the grain bin and may cause spoilage.

- **Add wheat to drying bin in shallow layers until the moisture content decreases.** High moisture wheat (18%-20%) can be added in 4 ft layers on top of dry grain if the fan can provide at least 3 to 4 cfm/bu through the total depth in the bin. As an example, 6 feet of 20% moisture wheat can be dried to 14.5%, then 4 more feet of 18%-20% moisture wheat can be placed on top of that. The fan must work against the static pressure developed by 10 feet of grain to provide at least 4 cfm/bu for the 4 feet of wet grain.

- **Level wheat inside each drying bin continuously – never allow coning to occur.** Some manual work may be required to maintain a level surface on the top when the maximum depth is reached. This will ensure uniform airflow through all the grain assuming it has been placed in the bin with a good spreader.

- **Use stirring devices when drying wheat if possible.** If stirring devices are used, the temperature can be set as high as 130°F (except 105°F maximum for seed wheat). Stir augers will blend the wheat sufficiently to prevent it from drastically overdrying near the bottom of the bin.

- **Monitor the moisture content of wheat daily.** Wheat must be cooled to avoid nighttime condensation on the inner walls. If the heat has been on long enough for the complete mass of wheat to be warmed and the weather is clear and dry with humidity below 60%, turn the heat off when the moisture content of the grain drops to within 1% of the target moisture content. Continue running the fans, and the residual heat in the grain will finish the drying process.

- **Aerate with natural air once the grain is below 13% moisture content.** Wheat should be cooled as much as possible with early summer conditions. Cooling air should be checked for humidity, being careful to aerate when humidity is below about 60%, or better yet when the EMC is at or below the target moisture level. Avoid aeration with high humidity air since it will add moisture back to the grain.

- **Probe the bin periodically to check for insect infestation and grain temperature increase.** Wheat temperature increase usually

means moisture migration. Aerate whenever this is detected. If the problem is in the center of the bin and aeration is not effective, move the grain to another bin to solve this problem. Problems in the center of the bin usually indicate that a lot of fines and/or trash accumulated in this area during filling.

- **Never add more heat than necessary to adjust the humidity of the drying air down to about 55%**. The maximum heat needed, even in rain or 100% humidity, will be about 15°-17°F above the outdoor temperature. Adding too much heat can overdry the bottom layers of grain to as low as 8% which can greatly reduce the market weight. If the humidity range varies between 85%-100%, then add 15° temperature rise of heat. If the relative humidity is 75%-85%, then add 10° temperature rise of heat. If the relative humidity is 55%-75%, then add 5° temperature rise. If the humidity is 55% or less, use natural air (no heat) for drying.

On-Farm Drying Costs

It is very important to maintain the on-farm wheat drying cost at a minimum in order to maximize profits (return on investment). Producers interested in drying their wheat need to determine the total pounds of water they will remove from one bushel of grain. The number of BTUs to extract 1 lb of water will vary from 1,100 to 1,400 BTU/lb depending on how easily moisture is given up by the kernel. A good estimate is to use an average of 1,200 BTU/lb of water removed to calculate the energy needed to remove 1 lb of moisture. Table 10-7 summarizes the BTU/unit of fuels as well as the burning efficiencies.

Table 10-7. Heating value of fuel as well as their corresponding efficiencies.

Fuel	BTU	Unit	Burning Efficiency
LP gas	92,000	Gallon	80%
Natural gas	1,000	Ft^3	80%
Electricity	3,413	kWh	100%

Wheat drying costs may be estimated using the following equation(s):

Fan motor cost:

Fan motor cost ($/h) = fan HP × 0.7475 (kW/HP) × electricity cost ($/(kW-h)

Fuel cost:

Fuel cost ($/bu) = [(BTU/$lb_{water}$) × ($lb_{water\ removed}$/bu)× fuel cost ($/unit of fuel) × 100] / [(BTU/unit of fuel) × burning efficiency %)]

Wheat drying cost ($/bu) = fan cost ($/h) x drying time (h/bu) + fuel cost ($/bu)

Example 1:

Assume that a producer has a 30 HP fan with electricity cost at $0.10 kW-h, no demand charges are applied; determine the cost per hour of operation for this fan?

Fan motor cost ($/h) = fan HP (30) × 0.7475 (kW/HP) × electricity cost ($/kW-h) (0.10) = $2.25/h

Example 2:

Determine the drying cost per bushel of wheat to dry from 19% moisture down to 13.5% moisture using LP at a cost of $2.40/gallon.

Look at Table 10-3 for 19% wheat; it is determined that there is 4.07 lbs of water per bushel above the value for 13.5% wheat (64.07-60.00). The following is an estimate:

Fuel cost ($/bu) =
[1,200 × 4.07 × 2.40 × 100] /
[92,000 × 80%] = $0.16/bu

On-Farm Wheat Storage

The safe wheat storage period is affected by its moisture content and temperature. Figure 10-5 shows the effects of wheat temperature and moisture content on the duration of storage. It is clear that the higher the wheat storage temperature and/or the higher its moisture content, the shorter

the safe storage duration. The following are a few tips that may help maintain the wheat quality during storage:

- **Remove the previously stored wheat before placing newly harvested wheat into storage bins.** Sweep the bin wall and floor as well as under the aeration ducts to get rid of grain kernels that may contain insect larvae and mold spores. Apply an approved insecticide both inside and outside the bin to delay insect population development before placing wheat in the bin.

- **Apply aeration to cool down wheat which was dried with heated air.** Aeration will control grain temperature even if it starts heating during storage, but this may only be a short-term solution to avoid further damage to grain quality. If aeration cannot control hot spots, move wheat to another bin to break up these hot spots.

- **Explore stored wheat conditions once a week during warm weather to protect it from deterioration caused by molds or insects.** Consider adding temperature measurement cables to monitor conditions during storage and an automated controller for aeration fans to start cooling stored wheat below 60°F as soon as possible in late summer.

- **Feel the top 6 to 12 inches of wheat to monitor temperatures and insect and mold activity.** Insert plastic insect traps below the grain surface to monitor insect activity and check them during weekly inspections to control damaging populations. Make sure to secure these traps to a fixed member of the bin.

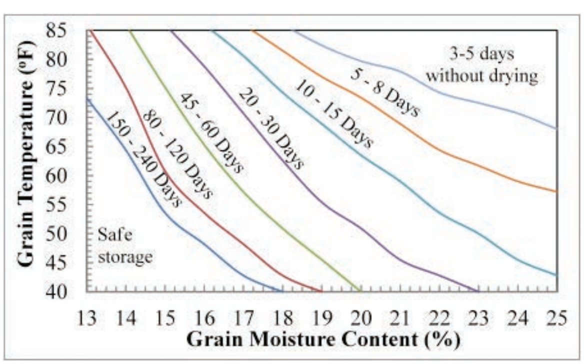

Figure 10-5. Effect of wheat temperature and moisture content on allowable safe storage time.

Safety Precautions and Practices

Working with moving grain requires special precautions and training. Therefore, check the following safety tips with coworkers and everyone who is supposed to work around grain bins.

- **Never enter a grain bin or gravity unload vehicle when grain is flowing.** Several accidental deaths occur every year during handling and unloading grain. Therefore, lock out the control circuit on automatic unloading equipment before entering or cleaning a bin or repairing conveyors. Flag the switch on manual equipment so someone else does not start it. Do not enter a bin unless you know the nature of previous grain removal, especially if any crusting is evident.

- **Avoid walking on any surface crust.** Crusted or bridged grain can collapse and could bury workers. Do not depend on a second person on the bin roof, on the ground or at some remote point to start or stop equipment on your shouted instructions. If a grain bin is peaked close to the roof, be extremely cautious. Crawling between roof and peak can cave grain and block the exit.

- **Request help from coworkers when entering a bin.** When entering a questionable bin or storage, have two workers outside and one inside. Attach a safety rope to the man in the bin with the two men outside capable of lifting him out without entering the bin. One man outside cannot do this and cannot go for help while giving first aid. That person may fall or overexert in the panic and haste of getting off the bin or running to the control point.

- **Be careful when working around flowing grain.** Flowing grain can trap and suffocate a worker in seconds. Equipment noise can block out shouts for action or assistance. With modest flow rates of a 6-inch auger, a worker is helpless only 2-4 seconds after stepping into the cone of flowing grain. This worker will be totally buried in grain within 20 seconds at a grain flow rate of 1,000 bu/h.

- **Be wary and alert while working with out-of-condition grain.** Grain that has gone out of condition may have molds, blocked flow, cavities, cave-ins or crusting. Always wear a respirator capable of filtering fine dust to work in obviously dusty-moldy grain. Never work in such conditions, even with protection, without a second person on safety standby.

- **Run aeration fans for several minutes prior to entering a grain bin to ensure oxygen is present.** Stored grain can consume oxygen from the air within the bin and suffocate a person entering the bin.

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